

**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, D.C. 20554**

In the Matter of	)	
	)	
Expanding Flexible Use in Mid-Band Spectrum	)	GN Docket No. 17-183
Between 3.7 and 24 GHz	)	

**COMMENTS OF VERIZON**

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## **TABLE OF CONTENTS**

I.	INTRODUCTION AND SUMMARY .....	1
II.	VERIZON SUPPORTS THE COMMISSION’S CONTINUED COMMITMENT TO EXPANDING ACCESS TO SPECTRUM. ....	2
A.	The continuing need for more spectrum. ....	3
B.	Ongoing Federal efforts to identify additional spectrum. ....	6
C.	Staying ahead of the curve in the mid-band.....	9
III.	THE 3.7-4.2 GHZ BAND IS A CRITICAL COMPONENT OF THE 5G MID- BAND EQUATION.....	11
A.	The 3.7-4.2 GHz band is underutilized. ....	11
B.	The 3.7-4.2 GHz band is well suited to mobile broadband use. ....	13
C.	The Commission has tools to meet the challenges of permitting mobile use of the 3.7-4.2 GHz band.....	15
D.	There are numerous models and extensive experience for sharing or relocating.....	16
IV.	VERIZON SUPPORTS NON-INTERFERING UNLICENSED USE IN THE 5.925-6.425 GHZ BAND AND A MEASURED APPROACH IN THE 6.425-7.125 GHZ BAND. ....	21
V.	VERIZON ENCOURAGES THE COMMISSION TO MAXIMIZE THE UTILITY OF OTHER UNDERUTILIZED BANDS.....	22
VI.	CONCLUSION.....	23

## **I. INTRODUCTION AND SUMMARY<sup>1</sup>**

This proceeding marks an important next step in the Commission's continuing efforts to maintain global wireless leadership as we move into a 5G world. The mid-band spectrum in this proceeding offers particular promise in providing vital spectrum that will fuel 5G, especially given the potential for global harmonization of a portion of this spectrum. We urge the Commission to move quickly to a rulemaking proceeding.

U.S. policymaker and industry leadership has helped define global telecommunications of the first two decades of the twenty-first century, and the results are impressive. Not only do nearly all Americans have mobile phones and access to 4G LTE wireless broadband, but the majority of American adults have smartphones allowing them mobile access to the internet in most parts of the United States. And advanced networks, coverage, and smart devices drive use, so it is no surprise that per capita data use in North America greatly outpaces the rest of the world. According to some reports, by the end of 2017, data use in the United States is expected to be twice that of Europe, which has the second highest per capita data use in the world. Wireless communications have revolutionized the American way of life.

And there is more to come. The next generation of wireless technology – 5G – will provide much faster downloads, connect billions of devices, and respond within milliseconds. The U.S. telecommunications industry is in a global race to lead the world in 5G. With the right government inputs, U.S. industry should be able to build on its 4G success and set the pace for global telecommunications in next generation networks for the foreseeable future.

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<sup>1</sup> The Verizon companies participating in this filing are the regulated, wholly owned subsidiaries of Verizon Communications Inc.

Providing access to spectrum is one critical way that the government can pave the way for U.S. leadership in 5G. The Commission already has moved us expeditiously toward this goal by opening up several gigahertz in the millimeter wave bands for mobile terrestrial services. With its current inquiry into the use of mid-band spectrum between 3.7 and 24 GHz, the Commission has taken another key step in the right direction. Particularly important is its focus on the 3.7-4.2 GHz band. This band not only offers the possibility of large swaths of spectrum in much lower frequencies, it likely will be harmonized for next generation terrestrial mobile services throughout much of the world.

The Commission has been and must continue to be an integral partner in enabling the wireless industry to build America's wireless age. It has used creativity, vision, political will, and compromise to assist in identifying and developing opportunities for mobile broadband. By encouraging and adapting to new technological developments, favoring a flexible use framework, embracing a light touch regulatory philosophy, and innovating new methods and practices of spectrum use, the Commission has made the American wireless age possible. We now need the Commission to continue this important work and examine new and innovative approaches to making more mid-band spectrum available for flexible use, especially in the 3.7-4.2 GHz band. The Commission has taken an important first step with this Notice but now must move forward quickly to rulemaking.

## **II. VERIZON SUPPORTS THE COMMISSION'S CONTINUED COMMITMENT TO EXPANDING ACCESS TO SPECTRUM.**

Verizon and its competitors continue to experience staggering consumer demand for wireless data. We applaud the Commission's efforts to identify new spectrum resources to help wireless carriers meet that demand. The Federal government should make more spectrum available, especially in the 3.5-24 GHz range, in order to avoid a spectrum shortage that would

inhibit the growth, investment, and innovation in the wireless industry that has greatly benefited the American consumer. There is ample basis, particularly with respect to the 3.7-4.2 GHz and 6 GHz bands, for the Commission to move quickly from notice of inquiry to rulemaking.

**A. The continuing need for more spectrum.**

Recent data verify the exponential growth in demand for wireless services. Annual wireless data traffic has grown by a factor of 35 since 2010, to a staggering 13.7 trillion megabytes.<sup>2</sup> Wireless data traffic increased 238 percent between 2014 and 2016.<sup>3</sup> Today there are over 396 million wireless subscriber connections and 262 million smartphones.<sup>4</sup> Those figures represent an increase of 94 million subscriber connections and 184 million smartphones, increases of 24 percent and 70 percent respectively.<sup>5</sup> There are more mobile device subscriptions today than there are Americans,<sup>6</sup> 95 percent of American adults own a cellphone,<sup>7</sup> the overwhelming majority of which have smartphones,<sup>8</sup> per capita data usage in North America greatly outpaces the rest of the world,<sup>9</sup> and almost every American has access to wireless 4G LTE broadband.<sup>10</sup>

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<sup>2</sup> See CTIA, Wireless Industry Survey for Year-End 2016 (Dec. 31, 2016) (CTIA 2016 Wireless Survey), available at <https://www.ctia.org/docs/default-source/default-document-library/annual-year-end-2016-top-line-survey-results-final.pdf> (last visited Sep. 17, 2017).

<sup>3</sup> *Id.*

<sup>4</sup> *Id.*

<sup>5</sup> This increase is measured from subscriber connections reported through 2010. See Background on CTIA's Semi-Annual Wireless Industry Survey (2011), available at [http://files.ctia.org/pdf/CTIA\\_Survey\\_Year\\_End\\_2010\\_Graphics.pdf](http://files.ctia.org/pdf/CTIA_Survey_Year_End_2010_Graphics.pdf) (last visited Sep. 17, 2017).

<sup>6</sup> See CTIA Wireless Industry Indices Year-End 2016, Section II.B.I: Total Connections and Subscribers.

<sup>7</sup> Pew Research Center, "Mobile Fact Sheet" (Jan. 12, 2017), available at <http://www.pewinternet.org/fact-sheet/mobile/>.

<sup>8</sup> CTIA Wireless Industry Indices Year-End 2016 at

<sup>9</sup> See e.g., Ericsson Mobility Report 2017 at pg. 14 (showing that North America has the highest mobile device usage with traffic expected to reach 6.9 GB per month per active smartphone by

Wireless penetration is at 120.6 percent of the American population and, for the first time, more than half of all American households are wireless-only.<sup>11</sup> This growth in data usage shows no signs of slowing; in fact, it is only increasing as smartphone usage becomes nearly ubiquitous and data-intensive applications become more common and more inextricably merged with our everyday lives.<sup>12</sup> As impossibly high as today's mobile data usage may seem, Cisco projects that Americans will use more than five times as much data in 2021 as they used in 2016.<sup>13</sup>

Mobile applications that would have been unthinkable ten short years ago are consuming massive amounts of bandwidth today. Mobile streaming music and video, video calling, high-resolution photography, social media, and navigation applications all strain today's networks.

Verizon is not standing still. We continue to increase network capacity and improve network performance by aggressively developing and deploying the most advanced infrastructure and technologies, including: small cells; distributed antenna systems (DASs); in-building solutions; and LTE Advanced features, such as 4x4 MIMO, carrier aggregation, and 256

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the end of 2017. That amount is twice as high as Western Europe, the region with the second highest usage, based on Ericsson's report), available at <https://www.ericsson.com/assets/local/mobility-report/documents/2017/ericsson-mobility-report-june-2017.pdf> (last visited Sept. 25, 2017).

<sup>10</sup> See *Draft of Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993; Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services*, WT Docket No. 17-69, Twentieth Report (WTB 2017) at Web Table III.D.vi (Twentieth Report).

<sup>11</sup> Stephen J. Blumberg and Julian V. Luke, *Wireless substitution: Early release of estimates from the National Health Interview Survey, July-December 2016*, National Center for Health Statistics, CDC (May 2017), available at <https://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless201705.pdf>.

<sup>12</sup> See CTIA 2016 Wireless Survey (noting that there are now more wireless devices than American consumers, with about 1.2 devices per person, and that 95 percent of U.S. adults own a cellphone).

<sup>13</sup> See Cisco VNI Mobile Forecast Highlights (2016-2021), available at [https://www.cisco.com/assets/sol/sp/vni/forecast\\_highlights\\_mobile/](https://www.cisco.com/assets/sol/sp/vni/forecast_highlights_mobile/) (last visited Sept. 18, 2017)

QAM.<sup>14</sup> Verizon is continuously pushing the envelope on the newest technology advances.<sup>15</sup>

And we already are showcasing some of the potential applications for 5G, such as virtual and augmented reality applications, 360 degree and intelligent video, wearable devices, and autonomous vehicles uses.<sup>16</sup>

No one can predict for sure what new, high-bandwidth, low-latency, mass-market mobile services will make up the wireless landscape another ten years from now, but this push to 5G will definitely have economic impact. Some analysts predict that wireless providers will invest as much as \$275 billion nationwide over seven years to build out 5G or next generation networks.<sup>17</sup> This massive investment could create as many as three million new jobs throughout the economy and add as much as \$500 billion to the U.S. GDP.<sup>18</sup> Studies project that one quarter of subscribers in North America will be using 5G in 2022 and that there will be 1.5B IoT devices

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<sup>14</sup> See Verizon, Unparalleled network leadership by doing, available at <http://www.verizon.com/about/news/unparalleled-network-leadership-doing> (last visited Sept. 19, 2017).

<sup>15</sup> See Verizon, *Verizon, Ericsson and Qualcomm reach superfast 953 MBPS wireless speed in a dynamic, real-world environment deployment*, available at <https://www.verizon.com/about/news/verizon-ericsson-and-qualcomm-reach-superfast-953-mbps-wireless-speed-dynamic-real-world> (last visited Sept. 24, 2017) and Verizon, *Verizon, Ericsson and Qualcomm eclipse previous record with Gigabit LTE speeds reaching 1.07 Gbps in lab trial*, <http://www.verizon.com/about/news/verizon-ericsson-and-qualcomm-eclipse-previous-record-gigabit-lte-speeds-reaching-107-gbps-lab> (last visited Sept. 19, 2017).

<sup>16</sup> See Young, David “Experiencing 5G: demoing the blazin’ fast future of wireless,” Verizon Wireless Blog (June 8, 2017), available at <http://www.verizon.com/about/news/experiencing-5g-demoing-blazin-fast-future-wireless> (last visited Sept. 18, 2017); “Verizon and Ericsson showcase technology milestones and use cases demonstrating continued industry leadership in LTE, path to 5G at 2017 Mobile World Congress,” Verizon Media Center (Sept. 11, 2017), available at <http://www.verizon.com/about/news/verizon-and-ericsson-showcase-technology-milestones-and-use-cases-demonstrating-continued> (last visited Sept. 17, 2017).

<sup>17</sup> See “Smart Cities: How 5G Can Help Municipalities Become Vibrant Smart Cities,” Accenture (2017), at Pg. 1, available at [https://www.accenture.com/t20170222T202102Z\\_w\\_us-en/acnmedia/PDF-43/Accenture-5G-Municipalities-Become-Smart-Cities.pdf](https://www.accenture.com/t20170222T202102Z_w_us-en/acnmedia/PDF-43/Accenture-5G-Municipalities-Become-Smart-Cities.pdf) (last visited Sept. 25, 2017).

<sup>18</sup> See *Id.*

with cellular connections by 2022.<sup>19</sup> In order to fuel this growth and ensure that U.S. industry is at the forefront of the next generation of wireless services, the Federal government must make spectrum available in time for these types of innovation, not wait until after a crisis develops.

**B. Ongoing Federal efforts to identify additional spectrum.**

Verizon commends the Commission, NTIA, and other federal stakeholders for their combined efforts to open more bands for flexible use across the entire allocation chart. In each of these bands, the combination of ambitious and innovative government policy and industry support and collaboration have resulted in a more efficient use of spectrum that helps meet the differing needs of U.S. operators and better serves the public interests and economic good.

*Success in the Low Bands.* Over the last decade, the Commission has made great strides in opening low-band spectrum for commercial mobile use, both through auction of the 600 MHz, 700 MHz, Advanced Wireless Service (AWS)-1, and AWS-3 bands and by adopting more flexible rules in the AWS-4 and 2.3 GHz bands. The Commission is now working closely with federal partners at the Federal Aviation Administration, Department of Defense, Department of Homeland Security, and National Oceanic and Atmospheric Administration to study options for consolidating a diverse set of radar systems operating in the 1.30-1.35 GHz band to free 50 megahertz of spectrum for commercial flexible use.<sup>20</sup> Government and industry collaboration in bands below 3.5 GHz have helped lay the foundation for our country's nationwide mobile

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<sup>19</sup> See Ericsson, *Ericsson Mobility Report: On the Pulse of the Networked Society*, (Nov. 2016), at <https://www.ericsson.com/assets/local/mobility-report/documents/2016/ericsson-mobility-report-november-2016.pdf> (last visited Sept. 25, 2017)

<sup>20</sup> See Federal Aviation Administration, "SENSR Team Gets Green Light for Spectrum Analysis" (June 2, 2017), available at [https://www.faa.gov/news/updates/?newsId=88187&omniRss=news\\_updatesAoc&cid=101\\_N\\_U](https://www.faa.gov/news/updates/?newsId=88187&omniRss=news_updatesAoc&cid=101_N_U) (last visited Sept. 17, 2017)



networks and Verizon supports the Commission’s continued efforts to make more of this spectrum available.

***Strong Start in the High Bands.*** In the high bands, the Commission has demonstrated further vision in recognizing the potential value of millimeter wave spectrum for flexible use. Leveraging the lessons in sharing and relocation honed in the lower bands, the Commission has moved quickly in the “Spectrum Frontiers” proceeding to make millimeter wave bands available for next generation wireless services.<sup>21</sup>

Verizon is testing in the high-band spectrum and intends to make these bands part of its near-term 5G strategies.<sup>22</sup> As Verizon begins investing heavily in the millimeter wave bands, the Commission should reaffirm its commitment to the framework established in the *Spectrum Frontiers Order and FNPRM* and move expeditiously to certify the equipment that will deliver the 5G experience to American consumers. The Commission should also move expeditiously to issue the new flexible use licenses adopted in the *Spectrum Frontiers Order and FNPRM* to allow commercial deployment.

Verizon supports the Commission’s efforts to build on its strong start in the high bands, including new high-band opportunities for flexible use, as proposed in the *Spectrum Frontiers Order and FNPRM* and as further examined in recent industry filings.<sup>23</sup> We are encouraged by

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<sup>21</sup> See *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd. 8014 (July 14, 2016)(*Spectrum Frontiers Order and FNPRM*).

<sup>22</sup> See, OET Experimental License file no. 0144-EX-ST-2017 (stating a testing purpose of “[u]nderstand the characteristics of mmWave operating bands, specifically 28GHz”).

<sup>23</sup> See Letter from Scott Bergmann, CTIA, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 14-177, *et al.* (filed July 14, 2017).

Chairman Pai's announcement that he intends to present an order to the Commission to open more high-band spectrum for commercial use by the end of the year.<sup>24</sup>

***The Mid-Band Deficit.*** Unlike the pipeline for low- and high-band spectrum, the availability of mid-band, flexible use spectrum has remained largely static. In the last ten years, the 3.5 GHz band is the only band between 3 and 21 GHz that the Commission has attempted to repurpose for flexible use. Furthermore, while the Commission is working diligently to make the 3.5 GHz band available for broadband deployment, it has chosen a novel dynamic spectrum access model instead of the exclusive, flexible use, licensing approach that has been the successful hallmark of other mobile bands.

The 3.5 GHz band represents a unique opportunity to leverage 150 megahertz of flexible-use, mid-band spectrum for the next generation of wireless service and Verizon is committed to ensuring the success of the Commission's experiment in 3.5 GHz and eager to deploy in the band. In preparation for deploying in the 3.5 GHz band, Verizon has conducted extensive infrastructure and equipment testing with multiple vendor partners in both the lab and the field.<sup>25</sup> Verizon has also worked with a range of stakeholders through the CBRS Alliance, Winn Forum, and other industry initiatives to develop the standards, rules, and coexistence

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<sup>24</sup> Ajit Pai, Chairman, Federal Communications Commission, Remarks at Mobile World Congress Americas, San Francisco, CA (Sept. 12, 2017), available at [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2017/db0912/DOC-346666A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2017/db0912/DOC-346666A1.pdf) (last visited Sept. 20, 2017).

<sup>25</sup> See e.g., Verizon, *Verizon, Ericsson, Qualcomm and Federated Wireless team up to showcase first end-to-end band 48 CBRS carrier aggregation demonstration*, available at <https://www.verizon.com/about/news/verizon-ericsson-qualcomm-and-federated-wireless-team-showcase-first-end-end-band-48-cbrs> (last visited Sept. 19, 2017).

mechanisms necessary to enable efficient shared use of the 3.5 GHz band.<sup>26</sup> Verizon is encouraged by the Commission’s willingness to further consider the industry’s requests for narrow and carefully balanced refinements to its experimental sharing model.<sup>27</sup>

With only the experimental 3.5 GHz band in its pipeline, the United States is facing a mid-band spectrum deficit that could ultimately slow 5G deployment. All of the country’s mid-band eggs are in one basket, and that basket is untested. The Commission should, therefore, ensure that adequate mid-band spectrum is available, with sufficiently diverse spectral characteristics to bridge the gap between low-band coverage spectrum and high-band capacity spectrum.

### **C. Staying ahead of the curve in the mid-band.**

The term “mid-band” encompasses a wide swath of spectrum with vastly different propagation characteristics and features; that variety should lead to vastly different potential applications for mobile. Because “mid-band” as defined by the Commission spans over 21 gigahertz, bands at different points within the range are not necessarily functionally interchangeable. That variety makes it all the more important that the Commission consider the need for additional mobile spectrum throughout the range.

The 5G discussion often focuses on high-band spectrum and its predicted role in filling the capacity demands of the next generation of wireless technology.<sup>28</sup> While high-band spectrum – with its ability to provide high-capacity, high-speed, and low-latency broadband service – will

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<sup>26</sup> See Comments of Verizon, GN Docket No. 12-354, et al. (filed July 24, 2017)(discussing substantial Verizon infrastructure and equipment testing and standards development efforts in the 3.5 GHz band as well as particular concerns about the CBRS model).

<sup>27</sup> See *Id.*; see also CTIA Petition for Rulemaking, GN Docket No. 12-354 (filed June 16, 2017) at 4.

<sup>28</sup> This is not to suggest that the two bands have to be linked or that build out in one band would rely on build out in the other.

undoubtedly be very important to the 5G equation, mid-band spectrum could fill the critical gap between the high-band and low-band spectrum that will continue to serve as the foundation for network coverage and eventually fold into the 5G network architecture.

Mid-band spectrum could be used in conjunction with high-band spectrum to leverage the optimal capacity and coverage possibilities provided by each. Several novel deployment options are feasible such as using millimeter wave spectrum for downlink and mid-band spectrum for uplink,<sup>29</sup> or using millimeter wave spectrum for user plane data and mid-band spectrum for control plane information.<sup>30</sup> The potential applications of networks operating across low, mid, and high bands are limitless and are only beginning to materialize.

Mid-band spectrum will be important for 5G. As the Commission has pointed out, some of these bands are already being studied for mobile broadband use elsewhere in the world.<sup>31</sup> Commission leadership is needed to ensure that U.S. industry maintains its competitive advantages in this space. The international race to 5G will not be won in the high bands alone, but across the entire range of frequencies.

The Commission should continue to work with NTIA and other federal stakeholders to adopt a creative and proactive approach to identifying underutilized bands and reallocating spectrum to meet tomorrow's needs. As discussed above, much of the current spectrum used for mobile broadband services was repurposed through collaborative efforts between the Federal

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<sup>29</sup> See e.g. Description of Phazr Technology, available at <http://phazr.net/technology/> (last visited Sept. 22, 2017)

<sup>30</sup> See e.g. Intel presentation of 5G technology (describing a modem supporting 28 GHz and 3.3 to 4.2 GHz), available at <https://newsroom.intel.com/newsroom/wp-content/uploads/sites/11/2017/01/5G-pr-briefing.pdf> (last visited Sept. 24, 2017)

<sup>31</sup> See *Exploring Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Notice of Inquiry, FCC 17-104 at ¶ 2 (rel. Aug. 3, 2017) (“Mid-Band NOI” or “the Notice”).

government and commercial industry to allow for sharing and relocation of incumbent operations. The increasing spectrum needs of both Federal and commercial parties makes the identification of new spectrum opportunities more difficult, so cross-agency and public/private cooperative efforts may hold the key to better and more effective use of all spectrum resources.

The explosive growth in mobile broadband use has caused a surge in wireless broadband data demand. With the spectrum challenges on the horizon, the Commission should continue to take a leadership role in guiding Federal and commercial stakeholders in the effort to identify new spectrum opportunities.

### **III. THE 3.7-4.2 GHZ BAND IS A CRITICAL COMPONENT OF THE 5G MID-BAND EQUATION.**

#### **A. The 3.7-4.2 GHz band is underutilized.**

The 3.7-4.2 GHz band occupies 500 megahertz of spectrum immediately adjacent to the 3.5 GHz band, the only band currently in the Commission's mid-band pipeline. This 500 megahertz band contains more bandwidth than the Cellular, PCS, AWS-1, AWS-3, 600 MHz and 700 MHz bands combined make available for licensed commercial broadband services.<sup>32</sup> But, despite its potential value, the 3.7-4.2 GHz band is one of the most underused commercial bands. Verizon is encouraged that the Commission is taking a hard look at this 500 megahertz of optimally located spectrum.

***Underutilization by the Fixed Satellite Service.*** As the Commission notes in the Notice, the band provides space-to-Earth downlink transmissions from approximately 48 satellites to

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<sup>32</sup> The Cellular Band (50 megahertz), PCS Band (130 megahertz), AWS-1 Band (90 megahertz), AWS-3 Band (65 megahertz), 600 MHz Band (70 megahertz) and 700 MHz Band (70 megahertz) have a collective 475 megahertz of spectrum.

4,700 registered Fixed Satellite Service (FSS) Earth stations.<sup>33</sup> FSS uses in the 3.7-4.2 GHz band vary, and include a range of television and radio broadcast content delivery uses, backhaul, and telemetry.<sup>34</sup> But, while there are roughly 4,700 registered FSS users, there is no official accounting of how many earth stations are actually in service. A Google Fiber review of the Commission's FSS registration database and satellite imagery indicates a significant percentage of registered FSS sites simply do not exist.<sup>35</sup>

With respect to those FSS users actually operating in the band, a robust record demonstrates that the existing "full-band, full-arc" licensing structure is spectrally inefficient.<sup>36</sup> This licensing structure allows earth stations to coordinate both across the entire 500 MHz frequency band and the entire geostationary arc visible from their location, regardless of whether or not they are using, or have plans to use, those frequencies and satellite positions.

The "full-band, full-arc" structure allows FSS licensees to render large amounts of valuable spectrum effectively idle. Existing FSS earth stations sometimes use only a small portion of the 500 MHz in the band. While "full-band, full-arc" coordination may have been feasible (or acceptable) at a time when spectrum was less constrained, today it creates

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<sup>33</sup> Mid-Band NOI at ¶ 2.

<sup>34</sup> *Id.* at ¶ 14.

<sup>35</sup> See Comments of Google Fiber, RM-11778 (filed Jan. 9, 2017), at 9 ("Google Fiber Comments"); Reply Comments of Google Fiber, RM-11778 (filed Jan. 24, 2017), at 3-4 ("Google Fiber Reply Comments"). See also Alleven, Monica, "Google studying 3.7-4.2 GHz band for variety of applications," FierceWireless (July 26, 2017), at <http://www.fiercewireless.com/wireless/google-studying-3-7-4-2-ghz-band-for-variety-applications> (last visited Sept. 17, 2017) (indicating that as many as 29 percent of registered earth stations in the band may not exist).

<sup>36</sup> See e.g., *Petition for Rulemaking of Fixed Wireless Communications Coalition* in RM-11778 (filed Oct. 11, 2016) ("FWCC Petition"); Google Fiber Comments; Comments of Dynamic Spectrum Alliance, RM-11778 (filed Jan. 10, 2017) at 2; Comments of Federated Wireless, RM-11778 (filed Jan. 9, 2017), at 3; Comments of Mimosa Networks, RM-11778 (filed Jan. 9, 2017), at 4; Comments of Nokia, RM-11778 (filed Jan. 9, 2017), at 1-2; Comments of Wireless Internet Service Providers Association, RM-11778 (filed Jan. 9, 2017), at 3-4 ("WISPA Comments").

unacceptable inefficiencies.<sup>37</sup> In fact, the “full-band, full-arc” approach has even impeded the ability of other 3.7-4.2 GHz band incumbents to operate, hindering Fixed Service (FS) deployment in the band.<sup>38</sup> This inefficiency should give way to valuable flexible use spectrum rights that could be more diligently used by other parties and better facilitate sharing in the band.

***Underutilization by the terrestrial Fixed Service.*** Terrestrial FS point-to-point microwave links also use the 3.7-4.2 GHz band. As the Commission states in the Notice, however, FS use of the band has decreased substantially over time, to a relatively minimal 119 licensees.<sup>39</sup> Given the diminishing use of FS in the band, the availability of other FS microwave spectrum in other bands, and the existence of alternative, and often better suited, technologies for point-to-point data transmission, the Commission has numerous options for sharing with or relocating incumbent FS operations.

**B. The 3.7-4.2 GHz band is well suited to mobile broadband use.**

Opening the 3.7-4.2 GHz band for mobile use is a critical next step for maintaining U.S. leadership in next generation wireless. With its recent *Spectrum Frontiers* decision, the Commission has already placed a stake in the ground indicating its intent to dominate 5G.<sup>40</sup> Unlike that decision, allocating the 3.7-4.2 GHz band for mobile use already fully aligns with

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<sup>37</sup> See Google Fiber Comments at 6 (stating that “it is difficult to conceive that continuing to permit full-band, full-arc coordination in the absence of a specific need best serves the public interest”).

<sup>38</sup> See generally, *Fixed Wireless Communications Coalition Inc., Request for Modified Coordination Procedures in Bands Shared Between the Fixed Service and the Fixed Satellite Service*, RM 11778, Petition for Rulemaking (Oct. 11, 2016) (FWCC Petition); *Fixed Wireless Communications Coalition, Inc. Request for Modified Coordination Procedures in Bands Shared Between the Fixed Service and the Fixed Satellite Service*, RM-11778, Public Notice, Consumer and Governmental Affairs Bureau Reference Information Center Petition for Rulemaking Filed, Report No. 3059 (CGB, Dec. 9, 2016).

<sup>39</sup> *Mid-Band NOI* at ¶ 15.

<sup>40</sup> See generally, *Spectrum Frontiers Order and FNPRM*.

international efforts in the band and thus the band has greater potential to be globally harmonized. Mobile operators in many other parts of the world have focused on the full “C-band” – i.e., 3.4-4.2 GHz – over the last several years. GSMA, reflecting the views of a majority of its members, states that the C-Band is likely to form the basis for many 5G services around the world and that as much spectrum as possible should be made available within this range.<sup>41</sup> Today, in preparation for the ITU’s next World Radiocommunications Conference, WRC-19, wireless providers outside the United States are targeting the C-Band.<sup>42</sup> Maximizing mobile access to a portion of the C-band – 3.7-4.2 GHz – will be a key component to the United States continuing to lead the 5G race.

Similar to the neighboring 3.5 GHz band, the 3.7-4.2 GHz band has favorable propagation characteristics for small-cell mobile deployment. The ability of spectrum in the 3.5 GHz to 4.2 GHz range to carry significant capacity while providing non-line-of-sight propagation over longer distances than millimeter wave spectrum make these bands potential complements to high-band spectrum in integrated wireless networks. Coupled with high-band spectrum and under the right licensing regime, the 500 megahertz of bandwidth in 3.7-4.2 GHz can support the high bandwidth carriers required for data-heavy 5G services. And the 3.7-4.2 GHz band’s proximity to 3.5 GHz enables significant economies of scale, eases deployment, and leverages an existing and growing equipment ecosystem. Rather than creating overlapping or redundant networks and multiple builds, the band could be folded into 3.5 GHz deployments.

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<sup>41</sup> See generally, GSMA, “Use of C-Band spectrum for mobile broadband in cities: London and Shenzhen,” available at [https://www.gsma.com/spectrum/wp-content/uploads/2015/10/GSMA\\_C-Band\\_Report.pdf](https://www.gsma.com/spectrum/wp-content/uploads/2015/10/GSMA_C-Band_Report.pdf) (last visited Sept. 19, 2017).

<sup>42</sup> See Henry, Caleb, “ITU: mobile networks want some C- and Ka-band spectrum for 5G,” SpaceNews (Sept. 13, 2017), available at <http://spacenews.com/itu-mobile-networks-want-some-c-and-ka-band-spectrum-for-5g/> (last visited Sept. 17, 2017).



**C. The Commission has tools to meet the challenges of permitting mobile use of the 3.7-4.2 GHz band.**

Given the tools that the Commission has created and refined over the course of the last decade, the challenges of sharing spectrum with incumbents or relocating incumbent operations from the 3.7-4.2 GHz band are manageable.

The 3.7-4.2 GHz band has a relatively small and shrinking number of operating locations. As detailed above, there are only 4,700 registered FSS stations, of which a significant percentage may not be in operation.<sup>43</sup> And analysis of IBFS data reveals that new FSS licenses, renewals, and registrations have dropped precipitously in the last several years.<sup>44</sup> With respect to microwave, there are also only 119 FS licenses, representing a drastic decrease from the tens of thousands of licenses once held by common carriers.<sup>45</sup>

The advantages of such a modest number of incumbent operations are underscored by an even smaller number of actual incumbent licensees. A review of registered licensees in the Commission's databases reveals fewer than 1,500 unique FSS licensees, with less than one percent of licensees accounting for more than 30 percent of registered sites.<sup>46</sup> The Associated Press alone is licensed for over 900 sites, 15 percent of the overall total number of registered sites.<sup>47</sup> This high concentration of ownership of FSS earth station licenses could allow for easier Commission and cross-industry negotiation in determining the appropriate relocation or sharing approach.

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<sup>43</sup> Mid-Band NOI at ¶ 2.

<sup>44</sup> IBFS search conducted Sept. 20, 2017.

<sup>45</sup> Mid-Band NOI at ¶ 15.

<sup>46</sup> IBFS search conducted Sept. 20, 2017.

<sup>47</sup> IBFS search conducted Sept. 20, 2017.

The number of incumbent FS licensees is much smaller than that of FSS incumbents, with the most licensed to AT&T, GTT, CenturyLink, and Verizon.<sup>48</sup> Many of the FS incumbents in the 3.7-4.2 GHz band have natural incentives to share or relocate, such as taking advantage of potential opportunities to sell or lease mobile spectrum or provide mobile service in the band. Also, the mobile industry has extensive experience in successfully relocating fixed microwave incumbents (e.g., PCS and AWS-1/AWS-3) and such efforts have proven to be achievable without significant disruptions to the incumbent license holders.

**D. There are numerous models and extensive experience for sharing or relocating**

The Commission has a wide range of options at its disposal for how to best promote efficient use of the 3.7-4.2 GHz band. The experience gleaned from successfully repurposing spectrum in the AWS-1, AWS-3, 3.5 GHz, and 600 MHz bands is immediately applicable to the 3.7-4.2 GHz band. In particular, since all authorizations in this band are for commercial entities, the Commission can use market-based incentives to determine the band's best use.

***Scoping the Problem.*** Opening the 3.7-4.2 GHz band for mobile use and allowing the market to determine what services remain would be simpler than the outmoded and lengthy process of repurposing the spectrum by government fiat and forcibly moving incumbent satellite services out of the band. But, before the Commission can understand how best to implement flexible use in the band, it first must fully understand how the band is used and thus fully define the challenge of combining terrestrial and satellite use of the band. It can do so by undertaking a review of the 3.7-4.2 GHz band to correct the apparent errors in its registration databases.

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<sup>48</sup> ULS search conducted Sept. 20, 2017.

Preliminary inspections have revealed substantial discrepancies that significantly overstate the current use in the band.

***Models for Satellite.*** The fundamental challenge of permitting mobile operations in the 3.7-4.2 band is how to protect incumbent satellite earth stations, from terrestrial wireless interference.<sup>49</sup> Potential solutions to this interference concern include the following, either separately or in combination:

- **Relocation** – The simplest solution could be for the Commission to provide incentives for the satellite incumbents to relocate the C-band traffic to new frequencies, such as the Ku-band. Such incentives could range from the simple relocation rules that the Commission has employed in the past with microwave and broadcast auxiliary services to an incentive auction where licensees that wish to leave the band offer their frequencies for sale. Relocation of C-band traffic to higher bands has the advantage of providing the satellite incumbents with larger bandwidths while potentially allowing earth stations to use smaller antennas to receive the satellite transmissions. Some of the satellites in the band have a “bent pipe”<sup>50</sup> design and a review of Commission satellite authorizations reveals that the overwhelming majority of registered C-band satellites are also authorized Ku-band satellites.<sup>51</sup> Because these “bent pipe” satellites carry both C- and Ku-band transponders, the Commission should consider whether the Ku-band could accommodate C-band traffic with minimal equipment modifications. This capability could drastically

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<sup>49</sup> FSS uses the 3.7-4.2 GHz band for downlink and therefore terrestrial operations in the same band could create interference at the earth station.

<sup>50</sup> This means that the satellites simply repeat back to Earth what they receive from another earth station while providing only amplification and a shift from uplink to downlink frequency and without any onboard processing.

<sup>51</sup> IBFS search conducted Sept. 29, 2017.

reduce the cost and complication of transitioning satellite systems to new bands. With approximately 48 satellites in service, the Commission should be able to determine whether it would be feasible to move C-band traffic to another band.

- **Transition** – To the extent that FSS earth stations are located in urban or suburban areas, where fiber is generally more heavily deployed, the Commission could provide incentives for incumbent earth stations used for video program content distribution to move to fiber, which would exceed the capacity previously provided by satellite. The Commission should examine the viability of transitioning some of the incumbent earth station locations to fiber.
- **Repacking** – As mentioned above, the Commission currently authorizes FSS earth stations on a “full-band, full-arc” basis, resulting in each earth station being licensed and protected from interference over the entire 500 megahertz of the 3.7-4.2 GHz band. To the extent that relocation or transition are not feasible alternatives, the Commission should consider repacking satellite transmissions towards the upper part of the 3.7-4.2 GHz band. Certain of these incumbent earth stations have the capability to operate across the entire band.<sup>52</sup> The Commission should examine how much of the band incumbent

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<sup>52</sup> See e.g., Adaremi Atayero, Matthew Luka, and Adayemi Alatishe, Satellite Link Design: A Tutorial, 11 Int. Journal of Electrical & Computer Sciences, No.4, at 4 (noting that many earth station receivers in the C- or Ku- bands can accept all the signals from a satellite in a 500 MHz bandwidth), available at [https://www.researchgate.net/profile/Matthew\\_Luka/publication/235913554\\_Satellite\\_Link\\_Design\\_A\\_Tutorial/links/0fcfd514180f1382ce000000/Satellite-Link-Design-A-Tutorial.pdf](https://www.researchgate.net/profile/Matthew_Luka/publication/235913554_Satellite_Link_Design_A_Tutorial/links/0fcfd514180f1382ce000000/Satellite-Link-Design-A-Tutorial.pdf) (last visited at Sept. 24, 2017); Nelson, Robert, “Earth Station High Power Amplifiers” (Oct., 1998) (describing ability of earth station amplifiers to operate across full 500 MHz), available at [https://www.atcourses.com/sampler/Earth\\_Station\\_High\\_Power\\_Amplifiers.pdf](https://www.atcourses.com/sampler/Earth_Station_High_Power_Amplifiers.pdf) (last visited Sept. 25, 2017)

stations are using and whether those stations are tunable to the upper part of the band. If so, there may be modest cost or inconvenience in requiring that they operate only at the high end of the band and receive protection for only that portion that they actually use.

- **Sharing** – There is precedent for wireless sharing in multiple bands.<sup>53</sup> Because incumbent FSS earth stations are stationary and required to register in a database to receive interference protection, the Commission could couple this database with exclusion zones to prevent interference between terrestrial wireless and earth stations. Despite the Commission’s experience with such models, the database-driven sharing approach would likely be a more complicated solution than those mentioned above. Its viability would depend on numerous factors, including the size of required exclusion zones around earth stations. Particularly given the concentration of earth stations in urban and suburban areas, the sharing model should probably be considered in conjunction with the relocation, transition, or repacking approaches.

The Commission has substantial experience with each of these potential solutions and a combination of them may be appropriate. But, the Commission should adopt approaches that reflect the need for swift action. As discussed above, the rapid and unyielding increase in data consumption and the need to provide spectrum for 5G applications will not pause to accommodate a protracted process.

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<sup>53</sup> See generally, *Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz Bands*, Report and Order, 18 FCC Rcd 25162 (2003); *Amendment of the Commission’s Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz Bands*, Report and Order, 29 FCC Rcd 4610 (2014); *Amendment of the Commission’s Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Report and Order and Second Further Notice of Proposed Rulemaking, 30 FCC Rcd 3959, 3990 ¶ 94 (2015).

***Models for Microwave.*** There are likely fewer impediments to sharing, relocation, or transition for the FS microwave incumbents in the 3.7-4.2 GHz band because, as discussed above, these incumbents are fewer and have more naturally aligned incentives for facilitating flexible use in the band. Potential solutions to this interference concern include:

- **Relocation** – Similar to the FSS model above, the Commission should consider providing incentives for 3.7-4.2 GHz FS microwave incumbents to relocate to one of the other bands within the mid-band range with an FS allocation. While viable bands will be limited based on required link distances and propagation losses, given the small number of licenses, there could be opportunities to accommodate them.
- **Transition** – As with satellite, the increased deployment of fiber in certain areas may make fiber a viable alternative for some microwave deployments. Given the small number of impacted microwave links, the Commission could examine the possibility of transitioning these incumbent FS operations to fiber on a case-by-case basis.
- **Sharing** – The Commission has particularly applicable experience managing sharing between mobile and fixed microwave, having done so in the AWS bands. In the 3.7-4.2 GHz band, the existing database and small number of microwave links make sharing simpler and more manageable than in other bands.

Certainly, there is sufficient evidence for the Commission to move quickly from notice of inquiry to a rulemaking in the 3.7-4.2 GHz band.

**IV. VERIZON SUPPORTS NON-INTERFERING UNLICENSED USE IN THE 5.925-6.425 GHZ BAND AND A MEASURED APPROACH IN THE 6.425-7.125 GHZ BAND.**

*The 5.925-6.425 GHz band.* The 5.925-6.425 GHz band occupies 500 megahertz of mid-band spectrum and serves as the corollary Earth-to-space uplink band associated with the 3.7-4.2 GHz band. Together, these two bands compose the “conventional C-band.”<sup>54</sup>

As the Commission notes in the Notice, while the 5.925-6.425 GHz band has fewer FSS earth station licenses than its counterpart, it has unique satellite incumbents such as ship-borne earth stations and mobile satellite uses.<sup>55</sup> Most critically, the Notice also notes that the band is “heavily used for FS,” with over 27,000 point-to-point licenses in the band serving a range of uses including public safety and critical infrastructure applications.<sup>56</sup>

Verizon has several thousand microwave licenses in this band and believes it is critical that, whatever path the Commission chooses, it must protect incumbent use. This challenge is particularly compounded by the importance of these links to public safety and critical infrastructure entities. Verizon recognizes the need for a stable and interference-free operating environment for the public safety and critical infrastructure FS incumbents. That said, the proximity of the 5.925-6.425 GHz band to the 5.15-5.35 GHz and 5.47-5.725 GHz bands currently used by Unlicensed National Information Infrastructure (U-NII) devices makes it particularly attractive for unlicensed use. Verizon therefore conditionally supports unlicensed use in the 5.925-6.425 GHz band, so long as the Commission adopts rules that provide adequate protections to incumbent and future microwave deployments in the band.

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<sup>54</sup> See 47 CFR § 25.103.

<sup>55</sup> See Mid-Band NOI at ¶ 24.

<sup>56</sup> See *Id.* at ¶ 25.

***The 6.425-7.125 GHz band.*** The 6.425-7.125 GHz band is allocated to non-Federal FS, Mobile Service, and FSS in multiple overlapping allocations.<sup>57</sup> The absence of Federal incumbents and the existing mobile allocation for 100 megahertz within this band makes it more attractive for flexible use than many nearby bands.

However, like the 5.925-6.425 GHz band, the 6.425-7.125 GHz band hosts significant critical infrastructure FS incumbents.<sup>58</sup> Verizon believes that, while this band may hold promise for future flexible use, the Commission must also take a measured approach and ensure adequate protections to incumbent and future microwave deployments.

**V. VERIZON ENCOURAGES THE COMMISSION TO MAXIMIZE THE UTILITY OF OTHER UNDERUTILIZED BANDS.**

Across low-, mid-, and high-bands, the opportunities for clear, greenfield spectrum are largely exhausted. Every band will have incumbents and constituencies, and the Commission will need to constantly balance equities to find the best outcome for the public good. Verizon encourages the Commission to employ the same initiative, creativity and leadership that it used to free spectrum in the AWS-1, 700 MHz, AWS-3, 600 MHz, 3.5 GHz, and millimeter wave bands. The mid-bands contain underutilized spectrum that can be tapped for flexible use and help meet the needs of tomorrow's 5G applications.

There are opportunities to: (1) consolidate and rationalize complementary or non-interfering uses to fewer bands (e.g., FS microwave links); (2) leverage sharing approaches developed in other bands; (3) create economic incentives for incumbents to relinquish spectrum; and (4) move licensees to new bands with equally suitable characteristics. Verizon encourages

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<sup>57</sup> See *Id.* at ¶ 32.

<sup>58</sup> See Mid-Band NOI at ¶ 32.



the Commission to employ any and all of these approaches to free additional flexible use spectrum in the mid-bands.

## **VI. CONCLUSION**

In times of great need for additional flexible use spectrum, the Commission has consistently ensured that industry could access the necessary resources to meet consumer demand. It is clear, particularly with respect to the 3.7-4.2 GHz and 6 GHz bands, that the Commission has sufficient evidence to move quickly from notice of inquiry to a rulemaking. Verizon encourages the Commission to make that move and continue to lead the world in devising more effective and efficient means of using the nation's spectrum resources to help the United States to continue its leadership in the race to 5G.

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Respectfully submitted,

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